MECHANICAL STRESS FACTORS IN CONTROLLING THE GROWTH AND DEVELOPMENT OF MANDIBULAR CONDYLAR CARTILAGE.

J.C.V.M. Copray - University of Groningen, 9712 KZ Groningen, The Netherlands.

Craniofacial orthopedists have been seeking ways to control and manipulate growth processes in the craniofacial skeleton. An important site of growth for the orofacial region is the mandibular condyle. This structure significantly contributes to the ultimate shape and position of the mandible. In the embryonal and early postnatal stage, the mandibular condylar cartilage functions mainly as a 'growth' cartilage. -It should be stressed that this cartilage is a secondary type of cartilage which grows by apposition: in contrast to primary,interstitially growing cartilage (like epiphyseal cartilage) cell division only takes place in a thin superficial zone of mesenchymal prechondroblast cells, which loose their proliferative capacity after differentiation into functional chondroblasts.- With evolving functional activity of the temporomandibular joint the mandibular condylar cartilage gradually becomes merely an articular cartilage, a process which is attended by major structural adaptations. The evolving mechanical stress factors have been thought to modify the growth processes in the maturing mandibular condyle and to induce the functional remodelling of the cartilage.

To examine the influence of mechanical stress factors on growing mandibular condylar cartilage, we have developed an in-vitro device which makes it possible to apply small compressive forces on neonatal rat mandibular condyles in a serum-free culture system. We have monitored the cellular growth processes, the zonal architecture and the composition of rat mandibular condylar cartilage during culture without and with a range of continuously or intermittently applied forces.

It appears that, in the absence of mechanical loading, the serum-free culture environment allows proliferation, differentiation and matrix formation in the mandibular condylar cartilage to continue in a rate that seems to be linked to some intrinsic program. However, this autonomic rate of proliferation, differen-tiation and maturation results in an abnormal and fatal exhaustion of the prechondroblast zone after approximately one month of culture. Moreover, the serum-free culture system does not favour endochondral ossification, resulting in an inordinate increase in the amount of hypertrophic cartilage.

Our in-vitro experiments with the application of small compressive forces show that mechanical stress factors modulate this intrinsic rate of proliferation and matrix synthesis as well as the process of endochondral ossification. Dependent of the magnitude, the duration and application frequency, small mechanical forces can stimulate or slow down the rate of cell division and cellular metabolic activity. In neonatal cartilage a continuous force of approximately 5 mN increased proliferation in the mesenchymal prechondroblasts, while reducing the amount of synthesis of glycosaminoglycans and collagen by the functional chondroblasts. The same force applied intermittently (0.7Hz), by contrast, reduced proliferative activity, stimulated metabolic synthesis and increased the intra- and extracellular alkaline phosphatase activity in the entire hypertrophic zone. Apart from an effect on the rate of these cellular processes, the mere presence of a mechanical load appears to influence the direction of cartilage formation and the process of chondroblast differentiation.

The in vitro force application device can help to elucidate the transducer mechanisms and the cellular messenger systems that are involved in the regulatory influences of the mechanical stress factors on growing condylar cartilage.